

Atmospheric Plasma Depainting

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Outline

- **Problem Statement**
- **Define Plasma**
- **Define Atmospheric Plasma**
- **Describe Atmospheric Plasma Coating Removal (APCR)**
- **Benefits of APCR**
- **Introduce the PlasmaFlux™ APCR system**
- **Aerospace Depainting Efforts**
- **Navy Ship Depainting Efforts**



Problem Statement

- Annual cost of corrosion for DoD ~ \$22 Billion
- Virtually every weapon system across all segments of DoD require periodic maintenance of coating systems



Plastic Media Blasting



High Pressure Water Jet



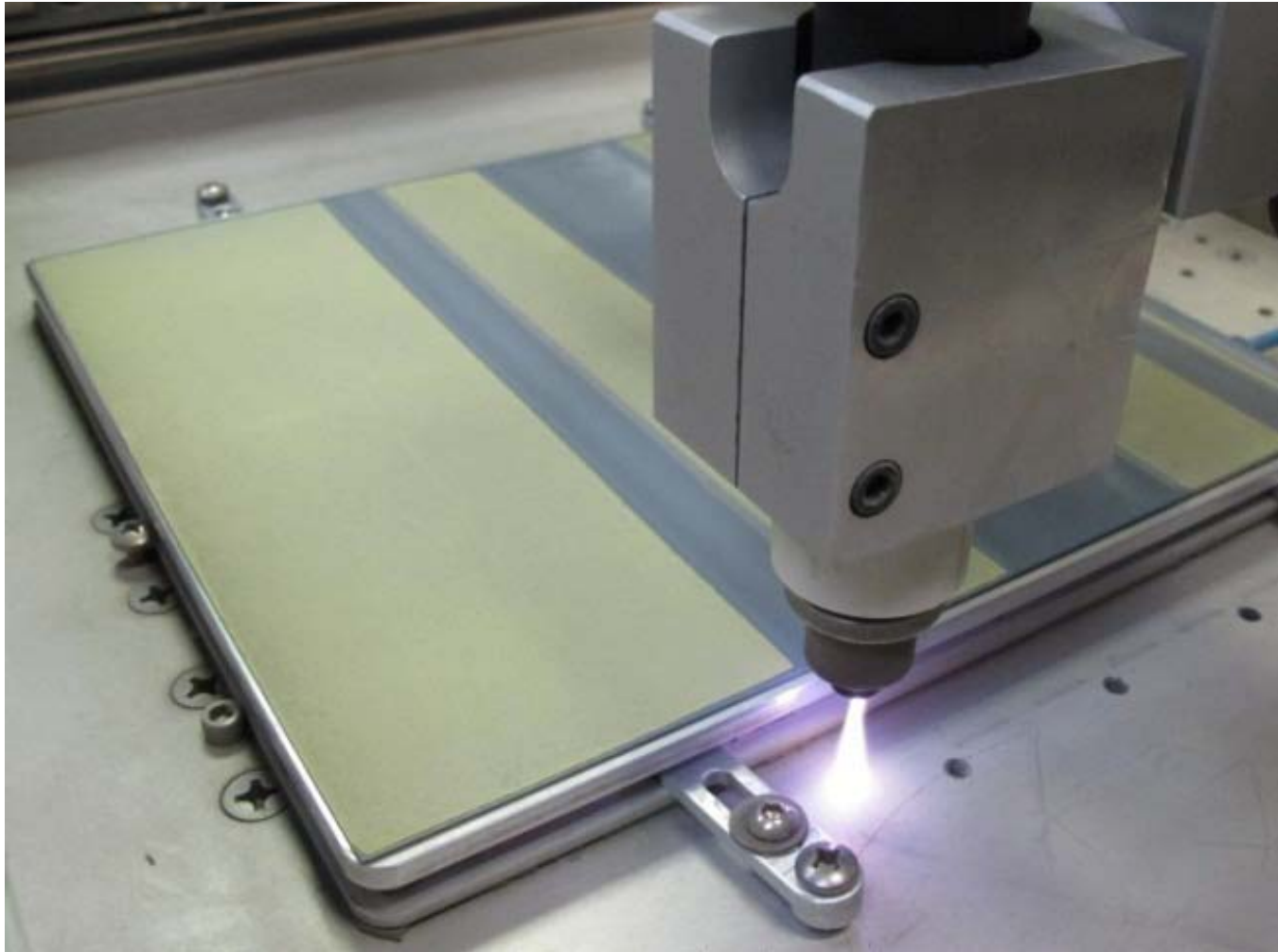
Grit blasting

Problem Statement

- Conventional paint and coating removal techniques are based on a variety of mechanical or wet chemical techniques.
 - Media based (sand/grit, dry Ice, and plastic media blasting)
 - High pressure water
 - Liquid Solvent Chemical stripping
- Disadvantages
 - Labor intensive
 - High materials cost (procurement, storage, transport, disposal)
 - High environmental cost (solid / liquid waste disposal)
 - Potentially damaging to some substrate materials (composites)



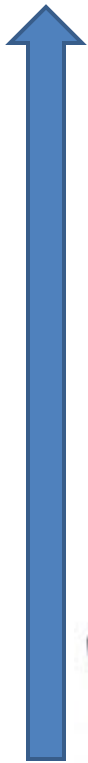
Solution: Atmospheric Plasma Coating Removal



What is Plasma?

Plasma: Fourth State of Matter

Increasing Energy



Solid



Liquid



Gas



Plasma



State of Matter

What is Atmospheric Plasma?



What is Atmospheric Plasma?

- **Plasma occurring at Atmospheric Pressure**
- **Plasma with Atmospheric Composition (Compressed air is only gas required)**

Atmospheric Plasma Coating Removal (APCR)



Atmospheric
Plasma

+



Paint / Sealant

=



Carbon
Dioxide



Water
Vapor

- APCR requires no media
- Atmospheric plasma produces highly reactive gas
 - Cold plasma \Rightarrow high chemical energy, low thermal energy
 - Vaporizes organic portion of coatings to CO_2 and H_2O
 - No damage to temperature sensitive substrates

Features and Benefits of APCR Technology

Feature	Benefit
No Media Required	Cost - Reduced procurement, storage, and disposal costs
	Safety - Reduced exposure to hazardous materials
	Environmental – Reduced environmental impact
Atmospheric Pressure Operation	Non-damaging removal, preserves surface profile
	Selective layer-by-layer removal
	Consumables: Compressed Air and Electricity
	Safety – No special safety equipment or procedures
	Cost – Eliminates need for “hot work” zones, faster maintenance cycle
Compact size, low weight	Controlled manually or by robotics
	Reaches areas that are inaccessible to other technologies

PlasmaFlux™ APCR Technology

Power Supply



Plasma Source



- The power supply produces a high frequency electric field to generate cold plasma
- Depot compatibility: Requires only compressed air and electrical power

Aerospace Depainting Efforts

- APC (Advanced Performance Coating), RAM (Radar Absorbing Material), and Sealant removal
- Aluminum, Titanium, Composite substrates
- Accessing confined spaces where other technologies struggle

Aerospace Depainting Efforts

APC on Aluminum
Removal to Primer

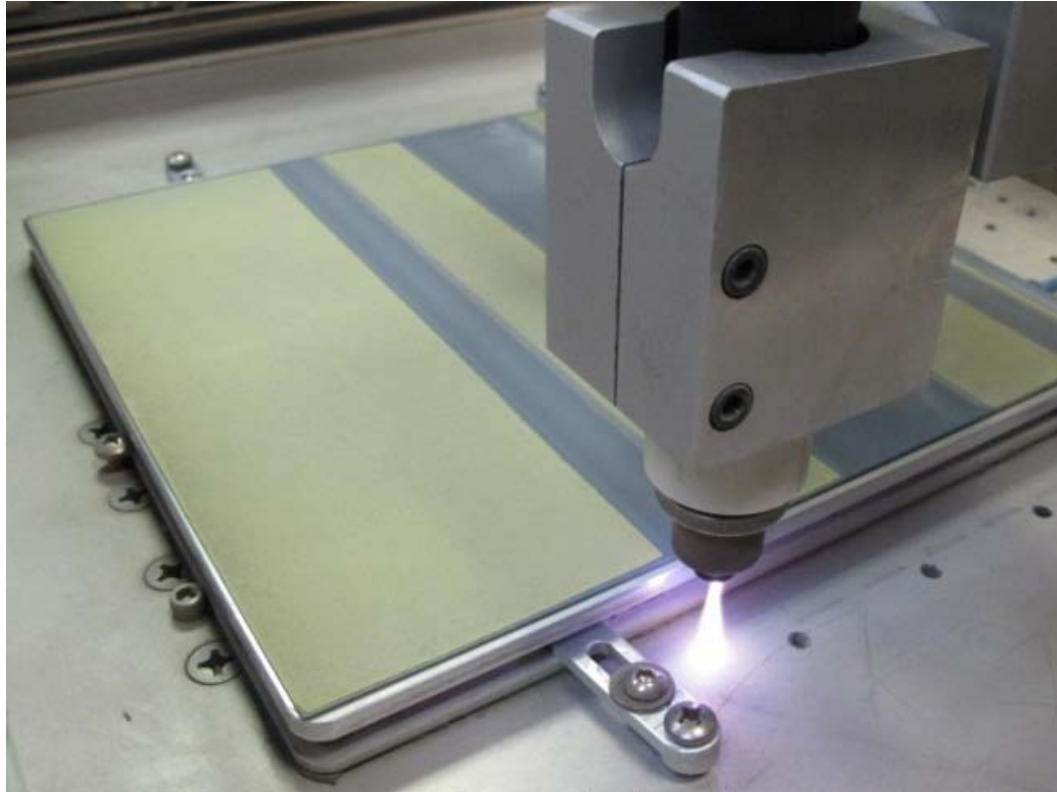
RAM on Carbon Fiber
Partial Topcoat Removal

APC Topcoat

RAM

Treated Area

Aerospace Depainting Efforts



- Selective layer-by-layer removal has been demonstrated on contoured substrates using 3-axis automated systems

Hand Held Removal of Polysulfide Sealant

**AC-240-B2 Sealant
(2-5 mm thick)
applied to lap joint with
protruding rivets**



**~15 second handheld
removal around rivet leaving
bare metal and powdery
residue**

Primer Removal, Sealant Removal

C-130 Aluminum Wing Corner Fitting



Primer Removal, Sealant Removal

C-130 Aluminum Wing Corner Fitting

Manual Treatments

Automated Treatments



Aerospace Coating Removal Transition Programs

- AFRL (WPAFB)
 - Evaluation of high power atmospheric plasma process for aircraft coating removal
 - Evaluation of handheld APCR for Sealant removal
- NAVAIR (Cherry Point)
 - Evaluate AP for weld surface prep on Nickel Superalloys
- Ongoing projects with prime contractors
 - Evaluating APCR for surface treatment of aircraft fasteners and sealant removal
 - Evaluating removal of specialty LO coatings on composite substrates

Naval Depainting Development Programs

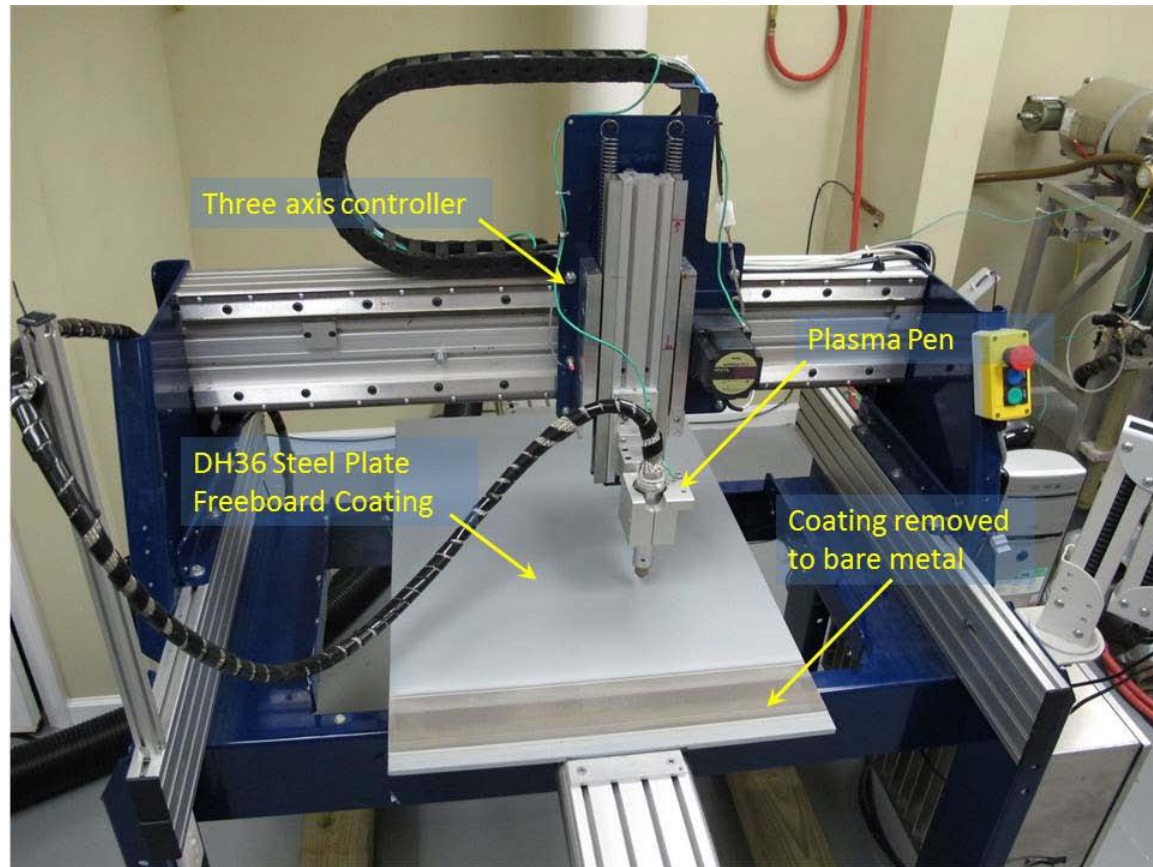
- Navy Phase I & II SBIR (N00014-10-C-0266)
 - Projects focused on engineering development challenges
 - Modular 20kW, Stackable Power supplies
 - Improved single and multi-pen designs
 - Ruggedization for Dry-dock environment
 - Operation using Dry-dock 480V 3-phase power

Naval Depainting Development Programs

- SERDP WP-1762 (NCSU Lead, APS Co-performer)
 - Recoating performance of APCR depainted surfaces
 - Multi-pen removal process development using SBIR designed plasma system
 - Removal rate enhancement on Naval ship coatings
 - Plasma plume-surface interaction
 - Environment, Safety and Occupational Health characterization of the plasma depaint process

Naval Coatings Removal

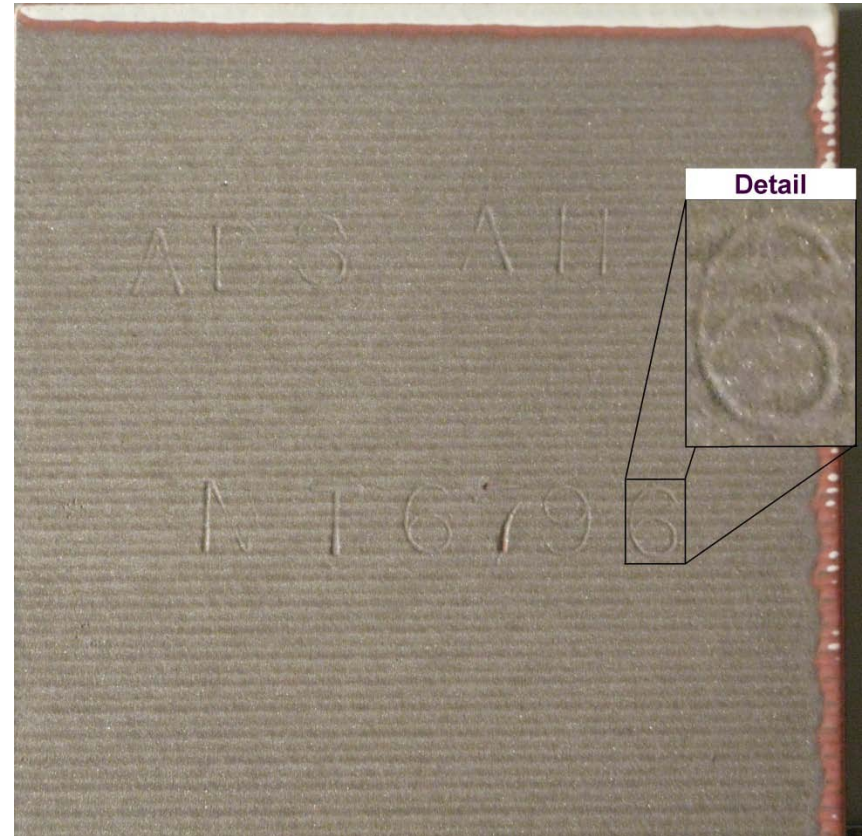
- Plasma pen integrates with COTS automated system for coating removal tests
- Sample coupons
 - 24" x 36" 3/8" DH36 steel
 - (± 2.5 mil roughness)
- Coating stacks
 - Freeboard
 - Anti-Fouling
 - 20 mils thick (nominal)



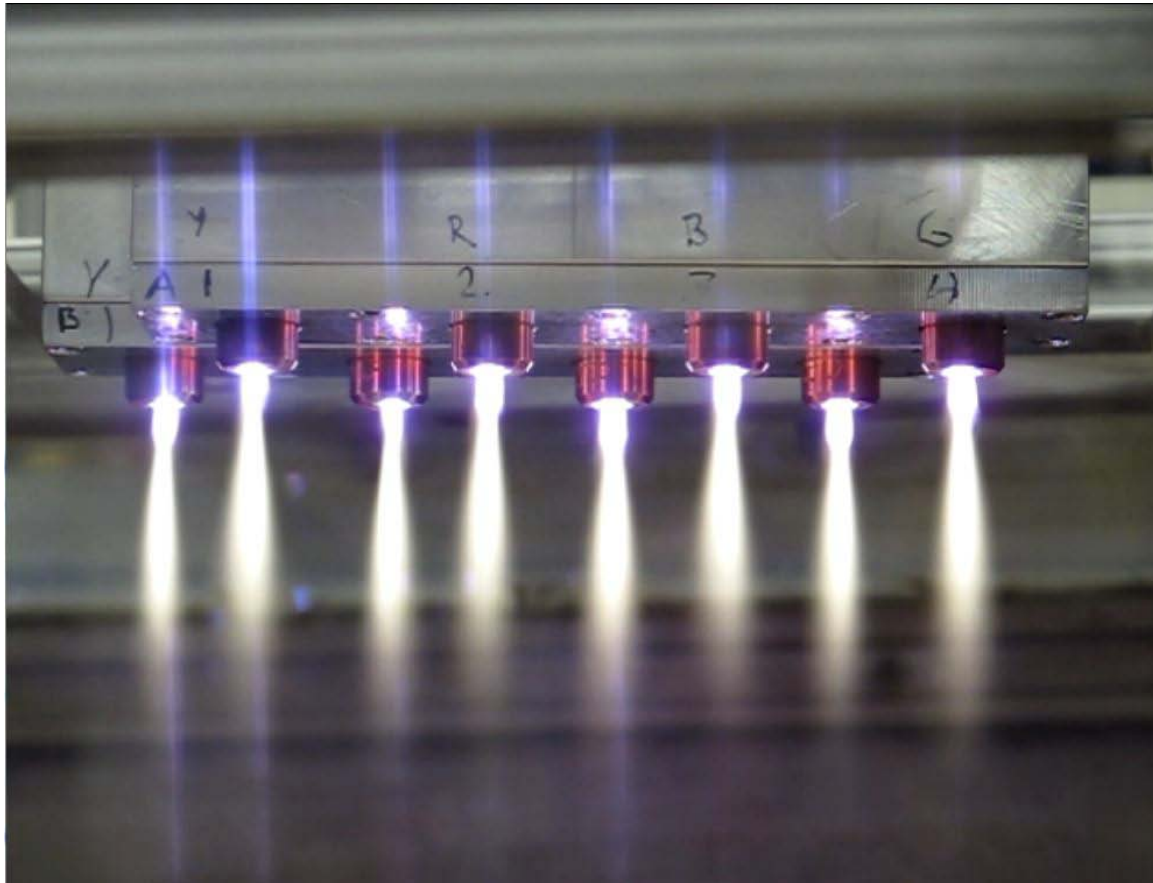
Three axis automated system

Anti-Fouling Coating Removal

- APCR produces surface with “near white metal blast cleanliness”
- Underlying surface profile is unchanged
- Uniform removal demonstrated for freeboard and anti-fouling coatings
- Demonstrated excellent adhesion of re-applied coating with no secondary wiping or cleaning required to recoat



APCR Multi-Pen Array



Eight Pen Array

SERDP Program Findings

- Comparable efficacy of APCR to conventional Naval coating removal techniques
- Test panels were depainted by grit blasting and APCR to “near white metal” conditions and then repainted
- No significant performance difference of reapplied coatings was observed between APCR and grit blast surface preparation
 - No discernible difference in surface grain size, structure, or composition.
 - Pull-off adhesion tests of re-applied coating are comparable
 - No significant coating performance difference in salt fog and cathodic disbondment testing

Solid Mass Reduction Study

Determine what % of coating is converted to vapor

- **Closed system employed during coating removal to capture solid waste**
- **Results indicate that up to 60% of coating mass was converted to gaseous byproducts**
- **EDS analysis of solid residue showed primarily inorganic content**
- **Freeboard Silicone Alkyd, PRF-24635 46% reduction**
- **Antifouling, 60% reduction**

Technology Transition

- **Scale up plasma coating removal technology to increase production rates**
 - Increased power levels (power source and plasma pen)
 - Multiple Plasma Pens
 - Wide Area Plasma Source
- **Ruggedize power supply and pen for testing under depot conditions**
 - Outdoor marine environment: Category III, Pollution Degree 4
 - Compliance standards taken into consideration in design

Technology Transition

- **Seeking Strategic Partnerships to further develop APCR technology for specific applications, demonstration and evaluation**

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Thank You,

Questions?

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Complete Integration of AP coating removal with High Performance Robotics

